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## SECTION OF GEOLOGY AND MINERALOGY

DECEMBER 4, 1939

PROFESSOR PAUL MACCLINTOCK, Princeton University: *Weathering of Glacial Till.* (This lecture was illustrated by lantern slides.)

The weathering of a drift sheet is accomplished by the downward-percolating meteoric waters charged with oxygen, carbon dioxide, and humic acid. The results of this weathering, however, differ to a considerable extent depending on the climate, the parent material, and the topographic position. Warm, moist climate, with its accompanying vegetation, results in lateritic weathering; *i.e.*, leaching of silica and residual concentration of iron; whereas, cool, moist climate with its appropriate vegetation results in podsolic weathering; *i.e.*, removal of the iron to leave a highly siliceous deposit. The constitution of the parent material obviously plays an important rôle, which is to be evaluated in each area studied. The topographic situation, together with the porosity of the parent material determines the rate and depth of percolation. Free and deep percolation, as in upland situations in porous material, gives rise to well drained profiles, whereas lowland and/or tight material result in poorly drained profiles.

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Associate Editor: Eunice Thomas Miner, Executive Secretary.

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The geologist has been able in some places to use the evidence from the depth and perfection of the profile to estimate the age of drift sheets. It, however, requires careful consideration of the variable factors mentioned above. Furthermore, in order to arrive at an age, it is essential that either the complete weathering profile be present or that the rate and amount of loss by surface erosion be known. If slope wash has removed the products of weathering as fast as they were formed, the record is obviously gone.

In New Jersey, there is Wisconsin drift, which has suffered so little weathering that only immature profiles are found, and an area of much older drift, which has suffered prolonged and deep weathering. However, in this latter area, the topography is so rolling that slope wash has removed material as weathering progressed and prevented the profiles from reaching maturity. As a consequence, judgment as to the age of the older drift is difficult. On the basis of its evidently prolonged weathering and the amount of erosion it has suffered, Salisbury originally considered most of it to be the equivalent of the Kansan, but a part of it to be intermediate in age between Kansan and Wisconsin. Later, he as well as Kummel thought the evidence for separation into two older drifts was not convincing and so placed it all in one glaciation. Later, Leverett revived the two-fold glaciation but extended Salisbury's intermediate drift considerably. The present study is an attempt at another technique of estimating age. Igneous pebbles, which are almost universally present in the drift were collected from uniform depth and uniform topographic position. They were then statistically analyzed as to the amount of weathering. The mean weathering of the pebbles in each exposure was then computed and plotted on a map. The resulting distribution seems to show three pre-Wisconsin drift sheets instead of two. This evidence from statistical analysis, however, must be considered in connection with other lines of evidence before final judgment can be passed.

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## SECTION OF BIOLOGY

DECEMBER 11, 1939

DOCTOR FRED H. ALBEE, Orthopedic Surgeon, New York, N. Y., and Venice, Florida: *Comparative Biology of Bone Reconstruction.* (The speaker illustrated his lecture with slides and a striking motion picture in colors, depicting actual operations in bone-grafting, at close range. Ed.)

Tree grafting was already an ancient invention with the Babylonians when they descended upon the pastoral Israelites and carried them away into captivity. Had it not been for this incident, the art might have been buried in the dust of antiquity with the Babylonion Empire.

But, along with the art of commerce—of which the Babylonians were past masters—the Israelites rescued it, and centuries later passed it on to the Greeks and Romans. The latter, being experimentalists and perfectionists, developed the art and precision of grafting to such a degree that their ancient writers left records of having successfully grafted grape vines and apple twigs on to poplars, elms, and locust trees. Repeated experiments in modern times, however, prove that the chance of successful propagation of such ill-assorted unions is one in a thousand.

Grafting, today, is confined within certain limits. As a general rule, the scion from one tree will not succeed on every other tree because the essential natural affinity is lacking. There must be a close relationship and similarity of structure between the stock and the scion, either as varieties of the same species, such as different sorts of apples; or species of the same genus, as apple and pear; or genera of the same family, as cherry on the plum or peach on the almond tree.

In spite of the claims that species of the same genus—such as pear scion on apple stock—will not thrive, Mr. James Halloway of Long Island, N. Y., has succeeded, because of his precision technique, in grafting a scion of English stewing pear on

the dwarf stock of a French crab apple tree. Moreover, it has borne fruit for many seasons. Another apple tree in his orchard bears 38 grafted varieties of apples.

Grafting is based on the power of union between young tissues. When the parts, that is, the stock and the scion, are placed nicely in contact, the ascending sap of the stock passes into and sustains life in the scion. The buds of the scion become excited by this fresh supply of sap and begin to elaborate and send down woody matter, which, passing through newly granulated substance of the parts in contact, unites the scion firmly with the stock.

A similar process takes place in bone union. Only, in place of the sap, blood rushes from the host to the cells of the graft and union takes place, first by deposition of soft callus and then by impregnation with lime salts.

The biological principles of plant grafting remain inviolable in bone grafting, precision of technique being the keynote. But the more highly specialized the animal tissue is, the more imperative it becomes that the graft be autogenous.

Reestablishment of sap circulation in the plant is less complex than reestablishment of blood circulation in human bones. For of all the layers in a tree—alburnum, heart-wood, and heart—the alburnum is the most important, for it is directly responsible for sap ascension.

But in the bone, especially long bones, all the layers—periosteum, cortex, endosteum and marrow—take part in the union.

Seventy-five per cent of the blood-supply to the cross-section of the long bone is furnished via the marrow cavity and 25 per cent via the periosteum of that bone. For this reason it is desirable to contact the bone graft with the marrow on both sides of the bone cortex, if possible, and still more so with the various layers.

Because of the exactitude of technique required and the brittleness combined with the knurly character of the bone, the chisel and mallet first employed were found inadequate. An electrically-driven, automatic cutting apparatus was needed, for the very life of this type of surgery depended upon it.

I was the first to design such an electrically-driven shaping mechanism, now known as the Albee Bone Mill. This Bone Mill consists of power-driven automatic cutting instruments of the male and female type, insuring precision fit of the graft into the graft-bed with the faultless accuracy of a glass stopper in a bottle. This is most important, for compression from poor fit may kill bone cells.

This precision fit supplies mechanical immobilization, immediate reestablishment of blood supply from host to graft, and places the least burden upon the osteogenetic or callus-forming properties of the bone.

Comprising this Bone Mill are the following instruments: a *lathe,* which shapes living bone pegs of various sizes; *dies,* which cut threads upon these pegs, converting them into screws; *taps,* which cut threads upon the drill holes; and a *universally adjustable twin saw,* which cuts graft beds for inlays of any size or shape.

This mechanism enables the surgeon to shape bone at the operating table under sterile conditions with the speed, facility, and accuracy of a machinist.

Relying primarily on precision technique, successful results have been obtained in cases where fourteen previous operations had failed.

Tibial bone having the highest degree of callus-forming property is usually employed for bone grafts. When it is insufficiently large, however, graft is taken from the ilium.

The only displacing force to be counteracted in the plant is that of the wind, while, in the bone, there is a constant pull of muscles, as well as their exaggeration by reflex from pain.

Sequential to union of tissues, either in plant or bone, there follows a series of mysterious processes summarized under Wolff's Law of Stress.

Under this law, the graft remakes its internal structure, alters its shape, and takes on volume and strength, in order to accommodate itself to the conditions and stress demanded of it by its new environment.

For instance, a graft the size of a lead pencil, when implanted to replace a portion of the thigh bone, because of stress demands, will take on the characteristics of the thigh bone shaft in strength, size, shape of cross-section, external contour, and internal architecture.

More than any other field, bone grafting emphasizes the importance of strict adherence to biological principles.

*Credit for Source Material*

*Scientific American,* Fred H. Albee, "Bone Surgery With Machine Tools." April, 1936.

Mr. James Halloway, 48 Dosoris Lane, Glen Cove, Long Island, N. Y.

Country Life Nurseries, Garden City, Long Island, N. Y.

# REPORT OF THE ANNUAL MEETING

## DECEMBER 13, 1939

The 121st Annual Meeting of the Academy for the election of Officers and Fellows, the presentation of reports and the transaction of other business was held at The Hotel Astor on the evening of Wednesday, December 13.

The Corresponding Secretary reported that there are now upon the rolls of the Academy 47 Honorary Members and 6 Corresponding Members. Two deaths were reported during the past year.

The Recording Secretary reported that, during the year 1939, the Academy held 8 Business Meetings and 26 regular Sectional Meetings, at which 27 stated papers, all of very high quality, were presented. Besides the Annual Dinner, the Academy acted as host at a presentation in the Hayden Planetarium arranged for the delegates attending the fiftieth anniversary celebration of the founding of the Geological Society of America. A lecture and informal reception was held on behalf of the Annual Meeting of the American Anthropological Society last December. Four informal receptions were held under the auspices of the various Sections of the Academy in honor of prominent out-of-town speakers.

The Section of Physics and Chemistry completed a most successful year made noteworthy by three two-day conferences on special subjects of research. They were attended by the most representative research workers in the respective fields from various parts of the United States.

Besides the above, an important two-day Astronomical Conference was held under the leadership of Professor Harlow Shapley, Director of the Harvard Observatory; Professor Henry Norris Russell, of Princeton University; and Professor Jan Schilt, of Columbia University, on the subject of "The Internal Constitution of the Stars." This marked an important extension of the conference idea in the Academy and won

the enthusiastic support of the twenty-six representative astronomers in attendance. This conference was the direct result of the important series of inquiries on the source of stellar energy initiated by President Morrison in connection with the astronomical prize competitions established by him during the past fifteen years.

The Recording Secretary thanked the Members of the Academy for their continued and increasingly active support of the undertakings of the past year. This is evidenced, not only by their steady demand for the publications of the Academy, but also by the impressive fact that more than 2,200 Members attended the meetings during the above period.

One Life Member, 7 Sustaining Members, 269 Active Members, 10 Student Members and 213 Associate Members were added to the rolls. Thus a total of 500 new members was added during the year.

The membership of the Academy is at present 1190, which includes 1 Patron, 96 Life Members, 162 Annual Sustaining Members, 470 Annual Active Members, 60 Student Members, 348 Associate Members, 47 Honorary Members and 6 Corresponding Members. Of these 202 are Fellows.

The Editor reported that one complete volume of the *Annals* and three parts of another have appeared. They are as follows:

"Molluscan Faunas of the Domengine and Arroyo Hondo Formations," by Harold E. Vokes, pp. 1–246. This paper constitutes the entire Volume 38.

The following three parts of Volume 39 were published:

"The Organization of The New York Academy of Sciences," pp. 1–28.

"The Morphology and Functional Evolution of the Atlas-Axis Complex from Fish to Mammals," by Francis Gaynor Evans, pp. 29–104.

"Electrophoresis," by Harold A. Abramson, Edwin J. Cohn, Bernard D. Davis, Frank L. Horsfall, Lewis G. Longsworth, D. A. MacInnes, Hans Mueller, and Kurt G. Stern, pp. 105–212.

The fourth part of Volume 39 entitled, "American Cities and States: Variation and Correlation in Institutions, Activities, and the Personal Qualities of the Residents," by Edward L. Thorndike, pp. 213–298, is scheduled to appear on December 22, 1939.

This year, the Academy established a new series, bound in cloth, to be known as *Special Publications*. The first volume of this series entitled "Climate and Evolution," by William Diller Matthew, pp. 1–224, has been published.

Three parts of "The Scientific Survey of Porto Rico and the Virgin Islands" have been printed:

Volume VIII, Part 3, "Diatomaceæ of Porto Rico and the Virgin Islands," by Robert Hagelstein, pp. 313–450.

Volume XIV, Part 3, "Insects of Porto Rico and the Virgin Islands," by Harry G. Barber, pp. 263–442.

Volume XVI, Part 2, "Polychaetous Annelids of Porto Rico and Vicinity," by Aaron L. Treadwell, pp. 151–320.

Volume XVIII, Part 1, "Porto Rican Archaeology," by Froelich G. Rainey, is now in galley proof, and will be ready for distribution early in January, 1940.

The last seven numbers of Volume 1, Series II, of the TRANSACTIONS, together with the title page and index for the 136-page volume have been printed and distributed.

The total number of pages printed to date since the first of the year in the *Annals, Special Publications,* "Scientific Survey of Porto Rico and the Virgin Islands," and TRANSACTIONS, combined is 1,302.

The Librarian reported that 7,928 separate publications were distributed to the members of the Academy, authors, exchanges and the sales list, classified as follows: *Annals,* 2,989; "Scientific Survey of Porto Rico and the Virgin Islands," 814; *Special Publications,* Volume I, "Climate and Evolution," 540; TRANSACTIONS, Volume I, 2,357; and "Man in a Chemical World," 1,228.

The Library of the Academy has received 2,407 publications from its exchange institutions.

The Treasurer reported that the surplus for the fiscal year ending November 30, 1938, was $14,762.00. During the past year ending November 30, 1939, receipts from all sources amounted to $15,718.14, making a total with the amount transferred above of $30,480.14. The disbursements for the past year amounted to $21,306.39, leaving a surplus as of November 30, 1939, amounting to $9,173.75.

The A. Cressy Morrison Prizes of $200.00 each for the two most acceptable technical papers in a field of science covered by the Academy or an Affiliated Society were awarded to the following papers entitled:

"Studies on the Nutrition of Colorless Euglenoid Flagellates," by Henry W. Schoenborn, New York University.

"The Structure and Relationships of *Protoceratops*," by Barnum Brown, The American Museum of Natural History, and Erich M. Schlaikjer, Brooklyn College.

Honorable Mention was awarded to the paper entitled "The Problem of the Scattering of the Fast Electrons," by John A. Wheeler, Princeton University.

Announcement was made that two prizes of $200.00 each will be awarded under similar terms at the Annual Meeting of December, 1940, and that an additional prize of $500.00 will be awarded at the same time to the most acceptable paper on the general subject of the sources of stellar energy. The precise terms of the competition will be published in a later issue of the TRANSACTIONS.

The following members were elected to Fellowship:

Fred H. Albee, M.D., Sc.D., LL.D.
Harold L. Alling, Ph.D.
Percy Laurance Bailey, Ph.D.
Russell L. Biddle, Ph.D.
McKeen Cattell, Ph.D., M.D.
Charles G. Darlington, M.D.
Gustav Egloff, Ph.D.
Charles E. Hadley, Ph.D.
John Eric Hill, Ph.D.
Frances Holden, Ph.D.
Laurence LaForge, Ph.D.
Victor K. LaMer, Ph.D.
Ralph Linton, Ph.D.
Harold N. Moldenke, Ph.D.
Frederick Osborn, A.B.
Thomas M. Rivers, M.D.
William J. Robbins, Sc.D., Ph.D.
Joshua Rosett, M.D.
Fordyce B. St. John, M.D., Sc.D.
Hugo H. Schaefer, Phar.D., Ph.D.
Rudolph Schoenheimer, M.D.
Theodore Shedlovsky, Ph.D.

Charles P. Smyth, Ph.D.
Daniel Starch, Ph.D.
Mary B. Stark, Sc.D., Ph.D.
Byron Stookey, M.D.
Harden F. Taylor, Sc.D.
George C. Vaillant, Ph.D.
Orlando F. Weber

Honorary Membership was conferred upon the eminent astronomer, Henry Norris Russell, Ph.D., ScD.

The following officers were elected:

*President*
Roy Waldo Miner
*Vice-Presidents*
Leslie E. Spock
Anne Anastasi
Horace E. Wood, 2nd
Ralph Linton
Victor K. LaMer
*Recording Secretary*
Duncan A. MacInnes
*Corresponding Secretary*
C. Stuart Gager
*Treasurer*
Wyllys Rosseter Betts, Jr.
*Librarian*
John Hendley Barnhart
*Editor*
Erich M. Schlaikjer
*Councilors* (1940–1942)
W. J. V. Osterhaut
Douglas W. Johnson
*Finance Committee*
Herbert F. Schwarz
John D. Sherman, Jr.
Wayne M. Faunce

After the Business Meeting, the following program was presented:

Address by the Retiring President
"The Practical Benefactions of Pure Science"
by
President A. Cressy Morrison

"Flight to the Stone Age"
by
Richard Archbold

Abstracts of these papers, and also those of the A. Cressey Morrison prize winners, are included in this issue of the TRANSACTIONS.

## NEW YORK ACADEMY OF SCIENCES

### Address of the Retiring President* given at Annual Dinner and Meeting

DECEMBER 13, 1939

PRESIDENT A. CRESSY MORRISON, New York, N. Y.: *The Practical Benefactions of Pure Science.*

The purpose of this address is to demonstrate the magnificent usefulness of knowledge gathered for its own sake, by showing some of its applications.

Brevity is necessary. I will therefore present but a few illustrations and discuss them as tersely as possible. Each illustration of necessity opens up vistas which are endless.

Thought is the most important force in the world. Thought gives rise to ideas. Ideas are more permanent than their materialization in visible things. A structure may easily be destroyed, but the idea which gave it birth may become immortal. Civilization, in all its ramifications, is a direct outgrowth of the vast accumulation of ideas. Pure science and its application is a manifestation of that something back of the human mind, which I believe demonstrates the existence of a supreme intelligence.

It so happens that a century ago, Goodyear and Daguerre made their very important discoveries. The connection between Goodyear's vulcanization of rubber and the airplane may be obscure to some, but it is direct. Latex to rubber, rubber to the pneumatic tire, the pneumatic tire to the perfected automobile and its light but powerful internal combustion engine, without which the airplane today would not be able to fly. Goodyear, therefore, has put the world on wheels, enormously developed our roads, and lifted Man into the air.

Daguerre discovered photography—step by step it has ad-

* Mr. Morrison served as President of the Academy during the years 1938–1939.

vanced. As early as 1869 the process which awaited the development of the film and the proper chemicals to produce picture in color was announced. The moving picture industry rests upon his discovery and its effect upon the world is already apparent. Who would have supposed that Daguerre's discovery, as now developed, would so improve the accuracy and facilities of astronomy that nebulae have now become island universes, space has grown from thousands to millions of light years, new radiations have been recorded, and photography has become the handmaiden of astronomy.

Michael Faraday's discovery of the principle of electromagnetic induction, was for him, the reward of an excursion into the unknown; the fruit of pure reason; an idea embodied ultimately in an experiment. To Faraday's contemporaries his discovery meant little or nothing. To those of us who live in this electrical age, Faraday's toy has become the foundation of a new civilization. It showed the way to harness the vastly powerful forces of electricity. Light, heat, power, and all the wonders which flow from the millions of electric dynamos and motors, which lift burdens of toil from our shoulders, delight and amuse us, employ simply and directly the principles of Faraday's discovery.

Whatever may have been Faraday's gift of prophecy, it is certain that he was led to this discovery, as to others, by an insatiable desire to learn and to know. No hope of other reward was needed to goad his active imagination. No vision of immediate usefulness spurred him in the search for truth.

Quite obviously, in our fast moving age, the long gap between Faraday's discovery and its application to human needs has been materially shortened by the development of vastly intricate industrial machinery to feed upon and utilize the results of researches in pure science. Obviously, too, the wealth created by industry is supplying the essential support and stimulus to research in pure science. President Conant of Harvard has described this relationship by a happy analogy drawn from the field of biology. He terms the mutual interde-

pendence of pure science, pursued for the purpose of increasing human knowledge and industry, whose objective is the creation of wealth in the broadest sense of that word, as "symbiosis" (living together). To make this meaning clear, he illustrates symbiosis by describing the process by which lichens live. A tender green plant synthesizes food for itself and also for a strong colorless fungus whose hardiness protects both from destructive forces. The application of the figure to the present subject and its aptness in describing it are evident.

Each phase of knowledge is connected by strings, often invisible, to a previous state of knowledge. Hence, we must give considerable credit to astronomy for things that are now of everyday use. Let me give some instances of fundamental ideas essential to further development of science, which have come from astronomy. The connections are so remote as to have become practically lost.

A mathematical equation devised by Clerk Maxwell has given us radio and television. The velocity of light was first discovered by Roemer from observations of the eclipses of Jupiter's satellites, and the notion of velocity of light or radiation was essential to the formulation of Maxwell's laws. A second instance of a very remote connection is Newton's law of gravitation and the principles of mechanics, which were arrived at on the basis of the motion of the moon. It is these principles that are the base of the entire complex of mechanical things that we possess at the present time.

Astronomy made necessary the study of optics. It has developed the strength of the human eye until it has become a two hundred inch reflector. It has, in the other direction, aided in the development of the microscope, until all the beneficent results of microscopic investigation are now in our possession and the end is not yet. The development of the study of optics and the correction of the imperfections of the human eye have given us the universal use of ordinary eye-glasses which has become one of the great factors in safety, in human enjoyment, and the advancement of education. Let us not forget, how-

ever, that the Chinese were two thousand years ahead of western civilization in the use of eye-glasses.

Navigation, aviation and surveying are based on the astronomy of the ancients, as was the discovery of the fact that the earth is a sphere. The calendar and the accuracy of our time are daily contributions of astronomy. The development of mathematics by the necessities of astronomy and the contributions of astronomy and physics to mathematics constitute a mutual obligation of great use to the world.

It is impossible to predict future uses of today's astronomy and doubtless many phases of it will never have any direct bearing on our daily life. However, modern spectroscopic investigations of matter in tenuous nebulae enable us to learn the behavior of matter under conditions that cannot yet be realized in any laboratory. In this field there is at least a probability of tangible results already forecast by the great practicability of many applications of extremely high vacuum.

We are indebted to astronomy for the spectroscope, which discloses with marvellous accuracy the constituents of matter found throughout the universe, but few realize that this same instrument is now in practical use in hundreds of laboratories, where it is disclosing immeasurably small amounts of impurities which may be useful or harmful in substances heretofore considered as pure. The majority of astronomers, if asked "What is the use of astronomy?," would probably quote Poincare, "L'astronomie est utile parce qu'elle est belle" (astronomy is useful because it is beautiful).

If we study the work of Copernicus and the impact of Galileo's pronouncement that the earth is not the center of the universe upon the ideology of the world, we find that it has changed and is changing the philosophy of every human being. If correct thinking is an advantage, perhaps in the field of ideology, one of the most valuable contributions of astronomy is the reaction to the emphasis which Galileo's discovery placed upon the insignificance of Man. This, at first resented, has now become an inspiration because of the better understanding

of the human intellect, its marvels and its complete superiority to the material. To force a realization of the amazing stimulus to research and the overwhelming effect of ideology upon Man, one needs but mention Darwin.

I cannot refrain from relating a curious fact regarding certain races of an age still veiled in the mists of antiquity. The wheel is so much of a commonplace that we seldom become conscious of its fundamental usefulness or the startling nature of its invention. The wheel was invented before history began. Its usefulness to Man and civilization is an unparalleled gift. To say that the wheel is the fruit of pure science would startle most of us, and yet the genius and research required for its development undoubtedly compare with some of the great discoveries of modern time.

To emphasize this point, it is only necessary to call attention to the fact that the civilization of the Mayas, Aztecs, and Incas was independently comparable with the best of the rest of the world at the time. It should be added that in mathematics and astronomy they had developed the fundamentals to so high a degree that their measure of time and the accuracy of their observations were equal to the best which civilization had developed elsewhere. These civilized groups in the Americas, dating back twenty thousand years, had enough genius to simplify their mathematical problems by their independent discovery of the cypher or its equivalent, and yet no wheel turned in America until the idea was brought to the new world by Columbus and his successors. One marvels that a civilization in prehistoric America possessed of such abilities in this field, as well as in other applications of science, should yet have been so backward mechanically as not to have invented that immensely useful device, the wheel. Our indebtedness to the obscure genius who invented and made practical the wheel is so great that we can never pay our obligations, but so far no monument has been erected to this pioneer in pure science.

Perhaps no single scientific discovery has had today such enormous and so valuable use as catalysis; invaluable tool of

chemistry. Indeed, there are few processes of chemical industry which do not employ such a promoter of one kind of another to accelerate and direct chemical reactions toward desired ends. Even the simple, universal reaction of combustion requires the presence of a minute amount of water vapor to allow it to proceed.

The ancients visioned the invaluable usefulness of the promoters of chemical reactions we now designate as catalysts and sought a universally active substance of the kind under the name of the "philosopher's stone." The advent of chemistry as a science directed attention toward these traces of extraneous substances necessary to bring about certain chemical reactions, and, more than a century ago, Berzelius had accumulated enough information on the subject to give phenomena of this type the name of "catalysis." Berzelius and a host of other investigators in the decades that followed pursued these inquiries without expectation of reward, but no intellectual pursuit has had more significant consequences. Sulfuric acid, as universally valuable in chemical manufacture as pig iron is in mechanical industry, is produced in our own country by the millions of tons annually by processes utilizing platinum, vanadium oxide and other materials as catalysts. Enormous tonnages of cottonseed no longer are wasted to clog streams and foul landscapes, because a catalytic process easily converts their oil content into a palatable, nourishing solid fat. The first World War was begun only after Germany was assured independence of imported nitrate for manufacture by the perfection of Haber's catalytic process for making the air supply this military essential. Though a military essential, how much more important is the fact of an unlimited supply of nitrogen to fertilize our cultivated fields and ultimately save the world from starvation. Our now commonplace, but still amazing, conquest by air of immense distances over continents and seas depends upon catalytically prepared fuels and catalytically controlled burning of them in internal combustion engines. What is true of air-borne commerce is quite as true of highway traffic in vehicles powered by similar fuels.

If the useful applications of catalysis stopped there, its value would already be incalculable. But it is only fair to say that these are but samples. They were chosen because they are clearcut. Beyond them stretch vast fields of catalytic reactions which lie at the very base of life itself. Because the processes involved in living organisms are intricate and complex beyond our present understanding, it is scarcely justifiable to class them with such simple chemical reactions as the synthesis of ammonia, the manufacture of sulfuric acid and the hardening of fats.

Yet the significant effects of minute traces of foreign matter on life processes point to their close kinship with other catalyses. The failure of certain farms to produce premium melons now, as of old, was ultimately traced to a depletion of the tiny traces of manganese in the soil. Traces of this element, so small that ordinary analysis failed to reveal them, were found essential to the growth of full-flavored melons. More intricate and equally essential are the vitamins, the hormones and the auxins which, in minute traces, control life processes. These are rapidly becoming tools of immense value in the hands of physicians and agricultural scientists as well, to improve all living creatures. Man, the animals, and Nature's bounteous luxury of plants are being made healthier, stronger and more useful by the applications of these products of pure chemistry.

A classical case in organic chemistry serves to illustrate the development of a chance discovery by an intelligent intellect actively inquiring into a fundamental fact of incalculable theoretical and practical importance. This is "substitution" or the replacement in an organic compound of an atom (usually hydrogen) by an atom of another element or by a radical (a group of atoms of two or more elements). Substitution was discovered by Dumas, when he was asked to find out why the candles at a ball in Paris gave off suffocating fumes when they were burning. Dumas learned that the wax had been bleached with chlorine, and he found that chlorine had evidently re-

placed some of the hydrogen of the wax, yet had not destroyed its essential nature. His published paper on what he had found is one of the classics of chemistry, but the idea in it was so new that it was met with jeers. It inspired the publication, in Liebig's Annalen, of an ironical paper written by Wöhler, but signed "S. C. H. Windler" (Swindler) who described some wholly imaginary experiments with a piece of cotton cloth. Step by step he replaced the hydrogen, oxygen and carbon of the cloth without changing its appearance or other properties, so that in the end the piece of cloth was composed of pure chlorine, yet indistinguishable from the original material.

In spite of the early disbelief and ridicule, the fact of substitution was soon well established and its application has influenced the greater part of the development of organic chemistry in the factory as well as in the laboratory. Without substitution, the chemist could never have produced the synthetic dyes or the hundreds of invaluable medicines. It is commonly said that the dyes are obtained from coal tar. The truth of this misleading statement is that a few essential compounds obtained from coal tar are the raw materials from which are built up, step by step, with the aid of substitution, the complicated molecules which meet hundreds of human needs. The enormous development of synthetic organic chemistry is the outgrowth of a simple but fundamental discovery.

The photoelectric effect was discovered by Hertz and Hall in 1887 and 1888 respectively, more or less through difficulties with experiments carried out for other purposes. The photoelectric effect underlies the sound effects accompanying moving pictures and it is absolutely essential for television.

"Marconi was inevitable," according to Abraham Flexner. "The credit for what has been done in the field of wireless belongs, as far as such fundamental credit can be definitely assigned to anyone, to Professor Clerk Maxwell, who in 1865 carried out certain abstruse and remote calculations in the field of magnetism and electricity. Maxwell reproduced his abstract equations in a treatise published in 1873. Other dis-

coveries supplemented Maxwell's theoretical work during the next fifteen years. Finally in 1887 and 1888 the scientific problem still remaining—the detection and demonstration of the electromagnetic waves which are the carriers of wireless signals—was solved by Heinrich Hertz, a worker in Helmholtz's laboratory in Berlin. Neither Maxwell nor Hertz had any concern about the utility of their work. They had no practical objective. The inventor in the legal sense was, of course, Marconi. But what did Marconi invent? Merely the last technical detail, the now obsolete receiving device called a 'coherer,' almost universally discarded." Yet no man will deny him the vast credit due for making pure science in this field of supreme importance to the world.

Edison's experiments with a metal plate carried on a platinum wire and placed alongside the filament in one of his electric lamps, led to the discovery of the so-called "Edison effect." His discovery, that when the plate is connected through a galvanometer with the negative terminal of the filament, no current will flow, but if it is connected with the positive end of the filament, a current will flow steadily through the galvanometer to the plate as long as the filament remains heated, is the basis of present-day vacuum tubes in universal use for radio communication and other purposes.

Entomology, devoted to the study of insect life, has already greatly aided humanity to win the bitter struggle against the vast hordes of insects competing for our food supply. A most striking illustration of the effective work of entomologists is the recovery of the continent of Australia from threatened depopulation by the swift spread of a fast-growing cactus. A million acres of valuable land were being occupied annually by cacti in an advancing wave no ordinary measure would stop. The entire continent was in danger of being engulfed, as sixty million acres had been, when entomologists suggested employing an insect which lives only on cactus plants. The *Cactoblastis cactorum* was finally brought in from Central America and by virtue of its prodigious appetite and enormous fecundity Australia has been saved for Man.

Australia was separated for millions of years from the mainland, and developed a balanced individual flora and fauna, but these had no protection when new plants, new animals or new insects were brought into Australia. So simple an animal as the rabbit became a pest. We may smile at the entomologists who measure the probosces of butterflies and bees, but the practical application of their studies becomes immediately apparent, as is well-known in connection with that very useful plant, red clover. It seems that Australia set out to grow clover, imported the seeds, and had successful crops for a year or two, and then the crops failed. It was then that the entomologists came to the rescue and imported bumble bees, the only insect that can fertilize red clover, and now clover grows.

Apropos of clover, one thinks of alfalfa. Pure research discovered that in Siberia, far north of the line where alfalfa can be grown in the United States, a species of alfalfa would survive. As a result of its importation and development, a strip 100 miles wide and 3,000 miles long in the United States can grow alfalfa successfully where none would grow before.

*Novius cardinalis* is a lady beetle imported from Australia to aid in the control of the scale insect *Icerya purchasi,* a pest of citrus and other fruit trees. It proved so efficient in California that it has now been imported to control the scale in all countries where scale is a pest.

The study of plant breeding, plant diseases and fungi has doubled the yields, improved the quality and often prevented the total loss of many of our most important crops. Can more be said for pure science and its applications?

The life history of the cattle tick discovered by Theobald Smith disclosed a method of control which is of untold value in preserving our food supply.

The theory of Sir Donald Ross and the story of how yellow fever was conquered as a result of the heroism and self-sacrifice of soldiers in our Army is too well known to be repeated here, but this work of the Army saves a million lives each year, or more than are killed by war.

Geology and paleontology are so closely linked that it is difficult in so brief a paper to adequately separate them.

The utility of geology as a means to the discovery of metals, minerals, oils, and the location and physical characteristics of materials for dams and other structures is so apparent that we cannot walk a paved street anywhere in the world but that its geological relationship echoes with every footstep. The search for the remains of prehistoric animals had led to discoveries of prime importance in all directions. But civilization, while based on material things, is equally dependent upon the increase of human knowledge. The greater our understanding of the structure of the earth and the history of living creatures through an almost infinite past, with their ultimate relationship to Man, the more the mind of every thinking person broadens, better judgment develops into tolerance and understanding. These contributions may do more for the elevation of the mind of Man, the real objective of human life, than can be gained from developments which add merely to Man's security and comfort. Let us then tread the earth with reverence.

Early attempts to measure the constant of gravitation using the torsion balance provided experience which has made possible one and perhaps the most important form of geophysical prospecting now used to find oil.

Dalton's Atomic Theory and Mendeleeff's Periodic Law developed the idea that all matter was composed of a limited number of kinds of indivisible building bricks, known to us as the atoms of the elements, out of which all things are constructed. While these concepts were indispensable as stepping stones to a better understanding of the structure of matter, they seemed to close the door to the possibility of anything outside of the material.

The discovery of radium smashed these bricks and transformed them into little constellations with a central nucleus, about which revolved electrons at infinitesimal, but relatively great distances from the nucleus. This opened the door to a

better understanding of forces, probably enormously more important to the ultimate destiny of Man than the material benefits which have already so magnificently followed the discovery of radio-activity in all its present applications. The unbelievable results derived directly from the discovery of X-rays are too apparent for emphasis.

One need but mention the ocean and the seven seas to bring to mind the unlimited fields for further research in the ocean as a source of food supply. How little we appreciate that the ocean and deposits of ancient seas are sources of our great preservative, salt, and how many think further as to the indispensable use of salt as a source of chlorine and caustic soda, both essential for the continuance of our chemical industries. How grateful we should be for chlorine which makes our vast city water supply safe and has almost conquered typhoid fever. Few know that the study of the locomotion of fishes has added to the speed of airplanes.

Investigation of the electrochemical equivalences of metals and alloys yielded data upon which are based the principle of using a thin film of one metal to protect another metal or alloy against corrosion. The most familiar example is the use of zinc or tin on iron. The corrugated iron roof of the tropics and the ubiquitous tin can are the result. No one can measure the effect on our food supply of the tin can.

I can draw from personal experience some illustrations of astonishing developments due to the electric furnace, beginning only as far back as the eighteen-nineties.

Gibbs' Phase Rule, which grew out of his profound studies of chemical and physical equilibrium, is the guiding principle in much of our development of alloys and it has certainly had a great influence over modern metallurgy. The real greatness of Josiah Willard Gibbs is slowly but surely becoming realized and, as an American scientist, he now takes his place as one of the first mathematical physicists of all time.

In considering the blast furnace as it was and is, we realize that its high temperature has, for certain reactions, been super-

seded by the higher temperatures of the electric furnace. Temperatures approaching 7000° Fahrenheit have been utilized for the production of calcium carbide and the ferroalloys. These alloys are intimate mixtures of certain elements with iron, and their usefulness is extraordinary. Calcium carbide, hence acetylene, has developed a universally used implement of industry, known as the welding and cutting torch. Acetylene is an endothermic compound, and when burned with oxygen gives the highest temperature in chemistry (6000°). This tremendous heat literally melts metals so that they fuse—hence welding. The details of the uses of this marvellous tool, a complete innovation, would make a volume in itself. Calcium carbide in combination with nitrogen offered the first practical solution of the nitrogenous refertilization of soils exhausted by over-cultivation. While, in this field, calcium cyanamide has been superseded to a large degree by other processes, nevertheless, it was the first practical answer to the vital question of the continuance of human life on the planet. Acetylene has become the base for large chemical industries and its usefulness is developing continually.

The very important alloys, ferrosilicon and ferrochromium, were first produced in the electric furnace in America, followed by ferrotungsten, ferromolybdenum, ferromanganese and many others, as well as by the invaluable artificial abrasives. The amazing effect of small quantities of alloying elements on steel would test credulity were it not daily demonstrated. The alloyed high speed tool used in working metals has accelerated many machining operations. A tool alloy of tungsten, chromium and cobalt has greatly hastened the cutting of metals, and a related alloy has more than doubled the life of wearing parts. The advent of aluminum, which is an electric furnace product, and its alloys has answered a thousand economic questions. An illustration not widely known but showing the usefulness of alloys is provided by the tools of cemented tungsten carbide that are used in the drilling of oil wells. This alloy has so increased the economy by which wells can be bored

that many thousands of feet have been added to the depth readily attainable. Thus enormously valuable new strata of the earth have been added to a field of exploration that, of course, comprises the whole land area of the earth. What this means is beyond our imagination. Vast deposits of the now universally essential crude oil and gas, and untold reserves of metals and materials are sure to be disclosed. Thus the whole development of metallurgy and economic advances are profoundly influenced by the alloys.

The Joule-Thompson effect deals with the change of temperature when a gas expands from a high pressure to a lower one. It is the basis of the process of liquefaction of gases and our present air-conditioning and refrigeration industries. I doubt whether any reader of the original scientific papers describing this discovery could have had any idea of the tremendous potentialities of the simple "porous plug" experiments as originally carried out.

Priestley's discovery of oxygen was followed by controversy, but he nevertheless was proved to be correct. Oxygen is our most abundant and active reagent. It has kept the hearth fires of the world burning since Man's beginning, yet its prodigious usefulness as an element had to await the discovery of a process separating it from the nitrogen and other gases of the air. Here again, research based upon the original experiments brought the answer in the liquefaction of air. Within the memory of the present generation, the discovery of the great industrial usefulness of oxygen as an element has been followed by a growth almost unparalleled in industrial history. It is essential in the oxyacetylene welding torch and it is equally essential in the cutting and shaping of steel parts. It has done its necessary part in replacing the tedious and almost impossible saw with a chemical knife that cuts steel almost as readily as an ordinary knife cuts cheese. Several billion cubic feet of oxygen are used each year. A hundred million cubic feet are used yearly in our hospitals, saving life and alleviating pain. Carrying this work further has brought

to light the usefulness of argon and neon, since electrified neon is the source of lights for the illuminated signs which now greet the eye everywhere. Argon is less conspicuous in one sense, but far more useful. The many years of pure research on the tungsten filament, glass and all the gases, which proved that argon could be used in the ordinary electric light bulb now so universal, has borne wonderful fruit.

In 1917, helium was a chemical curiosity that had been produced only in small quantities by investigators in pure science. Its discovery on earth had followed the findings of helium in the sun. On our earth where it could be bought at all, it then cost about $2,000.00 per cubic foot. However, technical men saw the possibility of extracting helium from natural gas for use in lighter-than-air craft and suggested it for military aeronautics. An efficient extraction process using the same principles was developed, by which helium could be secured in quantity at low cost. Helium is now produced at approximately one cent per cubic foot and in quantities sufficient for many uses.

In addition to the use of helium as a non-combustible lifting gas for airships, it is valuable for deep-sea diving and for medical purposes. Mixtures of helium and oxygen prevent caisson disease. Within the past year, new diving records have been made using helium. The medical profession now prescribes helium mixed with 20 per cent oxygen as a breathing atmosphere for persons afflicted with asthma, and this gives almost immediate relief. This humanitarian use of a once "rare" gas offers wide possibilities of medical application, according to reports by doctors who are studying the effects of helium on respiratory diseases.

The very fine work of separating helium from the mixed gases known as "natural gas" as it comes from the earth, meant the catching of one flying atom in every two hundred and passing on one hundred and ninety-nine to be used as fuel. This research taught us how to separate in purity all the other gases of the mixture, and on this rests our greatest organic

industry and one of ultimate supreme importance to the human race. By the use of natural gas and of waste gases from petroleum, by the use of coal and lime, and ultimately of oil shale, we are already producing in great variety extremely valuable chemicals and plastics, as well as textiles like silk or wool, and from these gases we shall ultimately produce food and drink.

This address is chiefly notable for what it of necessity omits, but these examples drawn from many fields of purely scientific inquiry show in unmistakable terms the enormous value of giving the searching imagination free rein. Even the calculations of astronomers accustomed to huge figures could not evaluate the wealth of comfort, convenience, health and happiness that stem from the researches I have mentioned. To forecast their effects on future generations is beyond human powers, great as these have been shown to be in other directions.

One is led by such speculations to the immediate conclusion that in this way lies peace on earth. Peace lasting through eternity because it will be based, not on petty jealousies and greed, but soundly on the sure foundation of plenty. The ancient prophet's vision of swords beaten into plowshares and spears into pruning hooks was the product of an agricultural age. Today, we envision secure and permanent peace based on turning a part of the wealth of nations, not into armaments, but into the manifold tools of science.

The irresistible conclusion to be drawn from the study of pure science and its application is that human thought, crystallized into ideas and materialized for the benefit of Man, is the foundation of every advance in civilization.

Science must begin with the student, and every opportunity must be given youth to gain a foundation for a life of Science. If human advance is to continue, the student must be liberally supported. He should be encouraged to visit museums where his interest will be aroused by the work of others. Our educational institutions have shown conclusively that they deserve every support, especially where they set students thinking.

The opportunities for education, even in the higher branches, should be broadened, for no one knows whence genius may arise. It may have its birth with the rich or the poor and, given opportunity, amazing ability will disclose itself from the most unexpected sources. The industries have at last learned the value of pure science, and today the real scientist need never go hungry, nor will he find his contemporaries inclined to quarrel with him. He has a free field. The industries, without any further incentive, will liberally support pure science and the man who can apply discovery. Scientific institutions, like The New York Academy of Sciences, bring together scientists for conferences and crystallization of ideas. These organized scientific bodies perform an extremely useful service. No man of science should fail to join and support his scientific organizations, for in them he will receive the stimulus of association with his fellows. In these organizations his theories will meet with scientific test without controversy, his papers will be discussed constructively, and his opportunities greatly enlarged. No philanthropist can make a better investment for the future of mankind than by supporting scientific education, scientific organizations, and pure scientific research and its applications. He will thus give the future the practical benefactions of pure science.

## NEW YORK ACADEMY OF SCIENCES

### Address given at Annual Dinner and Meeting

DECEMBER 13, 1939

RICHARD ARCHBOLD, Research Associate in Mammalogy, The American Museum of Natural History, New York, N. Y.: *Flight to the Stone Age.* (This lecture was illustrated by colored motion pictures and lantern slides.)

New Guinea offers a virgin field to the biological scientist. It is still comparatively free from the depredations of modern civilization. It is the last stand of the Stone Age Man. Roads are practically non-existent. The jungle and its flora and fauna may well be more or less as they were in the Pleistocene Era. Here is Natural History in the raw—the material which we hope will eventually supply the missing parts in that jig-saw puzzle which is the science of biology. New Guinea and other such isolated areas may some day offer the clue which will solve the mystery surrounding the beginnings of human life.

It seems ironical that we should still seek the clue to the beginning of human life while the world, in this advanced age, is intensively engaged in the business of ending life. War in Europe is once more threatening the foundations science has laid for civilization. What we have built to benefit mankind is being used to destroy mankind, and those who are serving in the cause of pure science are faced with the need to relinquish their researches or mark time.

Scientists here are also feeling the pressure. At least the war and its threat to our work have already been brought home to me. Because of chaotic international conditions, I've had to postpone my fourth expedition to New Guinea which was to begin in the latter part of 1940. The work that I hoped to finish there must now wait. But I do not propose to mark time. Within a month, members of my New Guinea expedition

will be at work upon life histories of animals in a section of the United States still incompletely studied by biologists.

The situation, as the war affects scientists in Europe, places an added responsibility upon American scientists. It becomes our duty to buttress the foundations science has constructed for civilization. We must double our efforts in all fields of scientific research lest the world we live in revert to the ways of the Stone Age Man as we found him in New Guinea.

Due to the absence of roads in New Guinea, transportation is the problem the explorer there must first solve. As a result of lessons learned on my two previous expeditions to that land of the cannibal and headhunter—the first in 1933 and the second in 1936–37—I chose a twin-motored, U. S. Navy PBY bomber, a flying boat with a cruising range of 4,200 miles, and removed the armament. After satisfactory test flights in the United States and West Indies, we left San Diego, California, on June 2, 1938, and flew by way of Honolulu and Wake Island to the expedition's base camp at Hollandia, Netherlands New Guinea, where we arrived on June 10th.

Waiting for us there and ready for field work were Dr. A. L. Rand, ornithologist; L. J. Brass, botanist; William B. Richardson, mammalogist, and Harold G. Ramm, base radio operator. An entomologist and a forester supplied by the Netherlands Indies government, a detachment of soldiers to protect the expedition from attack by inland tribes, as well as Dyak carriers, were also on hand. The complete personnel of the party numbered nearly 200.

Lake Habbema, 11,500 feet above sea level and about 150 miles from Hollandia, was to be our inland base. Since there was a possibility that our flying boat might not be able to take off at so great an altitude, a group of soldiers and carriers was first flown to a point on the Idenburg River from which they could make contact with Lake Habbema overland in the event that the first airplane party was marooned.

A rescue expedition, however, was not necessary. Throughout the year we remained in the field, we had no difficulty

getting the plane off the lake. Thanks to that good ship, we were able to explore and collect specimens over a wide area of unknown territory. Of the thousands of mammals, birds and plants we brought back, many of them have already proved to be new to biologists. An outstanding result of the expedition was a study made by Dr. Rand of the habits of the bird of paradise in its native habitat. So far as I know, this is the first time a scientist has been able to observe that bird in its own environment.

More spectacular, from the layman's point of view, was our discovery of a tribe which we estimated to number 60,000 and which showed evidence of never having seen a white man before. We found them in an unmapped valley of the Balim River about 3,000 feet above sea level. As we flew in, we noticed gardens ditched, terraced and protected by stone walls, extending for miles. From the air they looked like neat patchwork quilts as a meticulous New England spinster might put one together. We had seen native gardens before, weedy patches in small clearings, but never anything so well kept or on so grand a scale as these.

To our amazement we found they had wrested their gardens from the forest, using stone axes to cut down the trees and heavy wooden sticks wielded by hand in place of plows and cultivators. A closer inspection showed that they were good farmers, raising taro, sweet potatoes and pigs, and seemed to understand irrigation and the prevention of soil erosion.

When we met them they were usually friendly and often greeted us completely unarmed. Oddly enough, in trading with us, they scorned our steel axes and preferred cowrie shells for their pigs, vegetables and fruits. We soon discovered that they were not only good farmers but splendid engineers, knowing many tricks of modern suspension bridge-building, having such a bridge, made of limbs and branches of trees held together with rattan, across the Balim.

Although we did not plan it that way, our flight home also proved to be spectacular. By the time we reached Floyd

Bennett Field in New York we found that we had succeeded in making the first aerial circumnavigation of the globe at its widest diameter. Our route took us across Australia, the Indian Ocean, Africa and the Atlantic Ocean.

HENRY W. SCHOENBORN, New York University: *Studies on the Nutrition of Colorless Euglenoid Flagellates.* (A. Cressy Morrison Prize Winner, 1939.)

This is a fundamental contribution to the study of food requirements of animals. *Astasia* has no chlorophyll, and therefore no photosynthetic ability. Schoenborn has shown that this one-celled animal can be grown indefinitely in a solution of the following simple salts: ammonium phosphate, magnesium sulphate, potassium phosphate, potassium chloride, iron chloride and sodium acetate. *Astasia* requires no carbohydrates, no fats, no proteins, and has no need for any of the vitamins. From such simple chemicals, this animal is able to synthesize all of the substances fundamentally essential to living matter.

Use of the one-celled animals, or Protozoa, for experimental material simplifies tremendously the technical problems of the investigator. These simple animals carry on all the basic phenomena of life in the simplest possible form, without such things as endocrine organs, circulatory systems, digestive systems and other structures to complicate the interpretation of experimental results. In other words, life is here reduced to something approaching its lowest common denominator, to a simplicity which enables the investigator to comprehend at least some of the observed phenomena and even to control them within experimental limits. Such primitive animals can be subjected to rigidly controlled physical and chemical conditions. Furthermore, their food supply can be controlled, not only with regard to kinds of food but even to the exact amounts within a small fraction of a part per million. Under such conditions it is possible to determine exactly what chemical ele-

ments which are essential to living organisms. It also becomes possible to determine whether a need for vitamins and similar substances is a fundamental characteristic of living organisms, or whether such needs have been developed only by the higher organisms in the course of their evolution from simple ancestors. Such experimental material also promises much for the future in determination of the exact changes which animal cells produce in foods, and in the identification of chemical products which the simplest animals eliminate or else store as reserve materials.

Doctor Barnum Brown, American Museum of Natural History, and Doctor Erich M. Schlaikjer, Brooklyn College: *The Structure and Relationships of Protoceratops.* (A. Cressy Morrison Prize Winner, 1939.)

*Protoceratops,* meaning "first horned face," is the scientific name of a particular kind of dinosaur, whose fossilized skeletons were found in the Cretaceous red-beds of Shabarakh Usu, central Mongolia, by exploring parties under the leadership of Dr. Roy Chapman Andrews in 1922, 1923, and 1925. This was the species of dinosaur that laid the famous dinosaur eggs and the explorers collected and shipped home to the American Museum of Natural History in New York more than sixty splendidly preserved jaws and partial skeletons, nearly a dozen fine skeletons and several nests of the fossilized eggs. It took years of patient and skilled labor to remove the sandstone matrix (originally of wind-blown sand) in which the skeletons were buried and several more years of careful study of the delicate skulls of these animals. The skulls range from those of newly-hatched young just out of the egg, upwards through infancy, childhood and old age, to the largest supposed male skulls, which were about thirty inches long from the tip of the beak to the back of the bony crest on top of the head. The skull was composed of forty-six bones, each of which changed its shape gradually from infancy to old age. There were also

nineteen bones in the lower jaw and the authors describe and figure these and trace their changes from infancy to old age.

On the basis of extensive comparisons the authors conclude that during these individual growth changes the skull bones of *Protoceratops* were becoming more and more like those of the later horned dinosaurs of the Upper Cretaceous of western North America.

Doctor John A. Wheeler, Princeton University: *The Problem of the Scattering of Fast Electrons.* (Honorable Mention, A. Cressy Morrison Prize Contest, 1939.)

A quite serious discrepancy has existed between the observations of the scattering of fast electrons by matter and the accepted theory of the process. It has been thought that it might be necessary to assume that a yet unknown type of force exists in the atoms, and acts on the electrons penetrating them, in order to account for the observed experimental data. However, the author has shown that by taking into consideration the fact that the scattering substance consists of minute crystals that can diffract electrons, much as larger crystals diffract X-rays, it has been possible to develop a theory that accounts for the experimental findings. The result is an important one since it tends to confirm, for magnitudes of the order of the diameter of an atom, the validity of Coulomb's law, *i.e.,* that the force between two electrical charges is proportional to the product of the charges and inversely proportional to the distances between them. A possible cause of complication of existing theories of atomic structure and of interaction between the electron and nucleus has been removed.

# NEW MEMBERS

## Elected in December, 1939

### ACTIVE MEMBERS

Broadbent, B. Holly, D.D.S., Research Associate in Facial Anatomy, School of Medicine, Western Reserve University, Cleveland, Ohio.

Farnell, Frederic James, M.D., Assistant Neurologist, Presbyterian Medical Unit, Columbia University, New York, N. Y.

Furman, Martin A., M.D., Instructor, Otolaryngology, Columbia University, New York, N. Y.

Greenspan, Joseph, Ph.D., Instructor and Lecturer, Chemistry, Brooklyn College, Brooklyn, N. Y.

Iklé, Charles, Archæologist, New York, N. Y.

Kay, G. Marshall, Ph.D., Assistant Professor, Geology, Columbia University, New York, N. Y.

McDonald, Ellice, M.D., C.M., Director, Biochemical Research Foundation of The Franklin Institute, Philadelphia, Pa.

Piatt, Jean, Ph.D., National Research Council Fellow, Department of Anatomy, Columbia University, New York, N. Y.

Rosenow, Edward C., M.D., LL.D., D.Sc., Professor, Experimental Bacteriology, Mayo Foundation, Rochester, Minn.

Rusk, Hester M., A.M., Instructor, Brooklyn Botanic Garden, Brooklyn, N. Y.

Ryan, Thomas J., Teacher, Physiography and Physics, Bushwick High School, Brooklyn, N. Y.

Sayer, Arthur Robert, Ph.D., Tutor, Physics, Brooklyn College, Brooklyn, N. Y.

Schmelkes, Franz C., Ph.D., Biochemistry, Assistant Director, Wallace & Tiernan Co., Belleville, N. J.

Shapiro, Joseph, M.D., Assistant Neurologist, St. Johns Long Island City Clinic and Queens General Hospital, Long Island City, N. Y.

Vik, Esther Stubbs, Ph.D., Director, Field Laboratory and Instructor in Psychology, Child Education Foundation, New York, N. Y.

Walker, Alfred, D.D.S., New York, N. Y.

Washburn, Sherwood L., A.B., Instructor, Anatomy, Columbia University, New York, N. Y.

Wells, F. L., Ph.D., Psychologist, Department of Hygiene, Harvard University, Cambridge, Mass.

Willey, Charles H., Ph.D., Assistant Professor, Biology, New York University, University Heights, New York, N. Y.

### ASSOCIATE MEMBERS

D'Aunoy, Rigney, M.D., Professor, Pathology and Bacteriology, School of Medicine, Louisiana State University, New Orleans, La.

Gazin, Charles Lewis, Ph.D., Assistant Curator, Division Vertebrate Paleontology, U. S. National Museum, Washington, D. C.

Kraemer, Elmer O., Ph.D., Research Chemist, Biochemical Research Foundation of The Franklin Institute, Philadelphia, Pa.

Sanigar, Edward B., D.Sc., Research Physical Chemist, Biochemical Research Foundation of The Franklin Institute, Philadelphia, Pa.

Stier, Theodore J. B., Ph.D., Assistant Professor, Physiology, Biological Laboratories, Harvard University, Cambridge, Mass.

Swanson, William W., M.D., Associate Professor, Pediatrics, University of Chicago Medical School, Chicago, Ill.

Wakeham, G., Ph.D., Associate Professor, Chemistry, University of Colorado, Boulder, Colo.

Walters, Fred C., Ph.D., Associate Professor of Psychology, Director Research, University of Puerto Rico, Rio Piedras, P. R.

Ward, J. W., Associate Professor, Zoology, Mississippi State College, State College, Miss.

Weir, Wilbert Walter, Ph.D., Forest Ecologist, U. S. Forest Service, Tucson, Arizona.

Westheimer, Frank H., Ph.D., Instructor, Chemistry, University of Chicago, Chicago, Ill.